Agriculture as a Rich Context for Teaching and Learning, and for Learning Mathematics and Science to Prepare for the Workforce of the 21st Century

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Transitions from Childhood to the Workforce
Teaching and Learning Conference
September 17-19, 1999
Cornell University
Ithaca, NY

Prepared for:

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Table of Contents

Teaching and Learning Conference
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Agriculture as a Rich Context for Teaching and Learning, and for Learning Mathematics and Science to Prepare for the Workforce of the 21st Century

The Context

The basic core of agricultural education instruction consists of three intra-curricular components: 1) classroom instruction, 2) experiential learning through supervised experiences, and 3) leadership activities. When these three components are actualized through a well-designed integrated program, they provide a context for learning necessary content and life skills to prepare students for adulthood, regardless of their ideal career areas. The study of agriculture can also provide a context in which learners can explore key biological and mathematics concepts and skills. Many research studies have demonstrated that learners fail to develop deep understandings of science and mathematics in traditional classrooms and therefore fail to apply this knowledge to settings outside of the particular classroom.

Supervised Agricultural Experiences (SAEs) were implemented in 1942 as a response by the agricultural education community to Dewey's call to base education on the personal experiences of the learner (Dyer & Osborne, 1996). SAEs bridge the gap between the classroom and work by providing students opportunities to apply what they have learned in the classroom and to transfer those knowledge and skills to a real-world situation (Swortzel, 1996).

Leadership activities conducted through the FFA provide opportunities for students to learn about teamwork, public speaking and debates, writing for communication of ideas, and other skills identified as important for the worker of the future (SCANS, 1991). In addition, the FFA Proficiency Awards Program enables students to use their technical agriculture knowledge and skills in such areas as floral design, machinery repair, livestock judging, and milk quality testing in a real-world setting; these activities are judged and evaluated by individuals practicing in the field. Combined with record books used with SAEs, students have the maximum opportunity to practice and demonstrate real-world problem solving, communication skills, and application of classroom knowledge to a new situation. In addition to these important opportunities for learning, most agricultural education programs engage in several community service activities per academic year, engaging students with their community and with citizens in need. These activities include tutoring younger students, providing lawn maintenance for senior citizens, stream clean up, playground equipment instruction, and others.

Science and mathematics have always been basic tenets of agricultural instruction in the United States. Agriculture by definition is an applied science that combines principles of the physical, chemical, and biological sciences in the process and production of food and fiber (Merriam Webster, 1988). The field of agriculture as an industry has also changed drastically since the inception of agricultural education. The small family farm that was the norm for American agricultural producers is now the exception. Agriculture today is a highly intensive, technologically sophisticated industry. These factors led the National Research Council to recommend that agricultural education programs must update and integrate more agricultural science into their course content, a contention echoed by Martin, Rajesekaran, and Vold (1989). Nationally, the field of agricultural education has recognized a definite need for the integration of more scientific and mathematics principles into agricultural instruction.

Beyond the opportunities for learning and practice provided through SAEs and the FFA, students enrolled in agricultural education receive instruction and reinforcement of science and mathematics principles within the context of agriculture. Research has shown that using agriculture improves the acquisition of basic science and mathematics process skills of elementary students (Mabie & Baker, 1996). Students studying aquaculture in an agriculture program reported that their achievement in science and mathematics classes was higher as a result of their participation in agriculture based on comparisons with their past performances in those classes (Conroy & Walker, 1998). As one specific example, a secondary agriculture program in North Carolina reports using chemistry, biology and math in an integrated manner in their program using a closed aquaculture recirculation system, pond, and caged pond production methods Mooring & Hoyle, 1994, as cited in Conroy & Walker, 1998). Another example of the interdisciplinary nature of agricultural education is a program that uses classroom aquariums to teach a curriculum that integrates aquaculture production and maintenance principles, technology, and sociology in an interdisciplinary model (Figure 1) (Brody & Patterson, 1992).

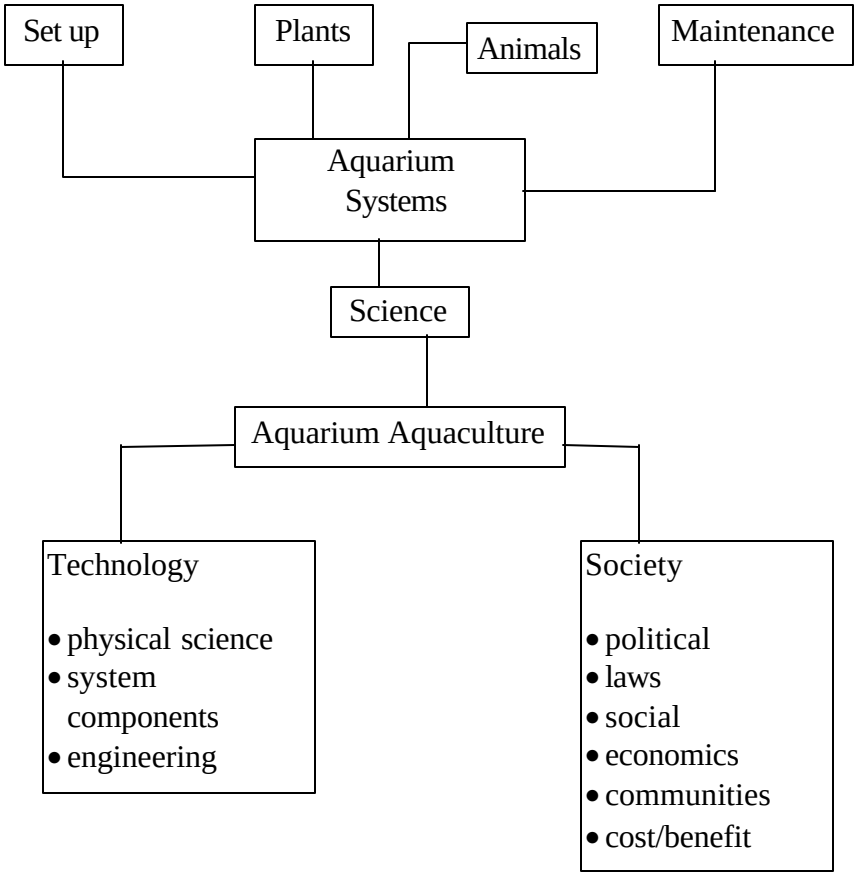

Figure 1. Instructional Unit Design for Aquaculture

SOURCE: Brody & Patterson, 1992, p. 38.

Teachers can also develop programs that include economics, computer skills, and rural sociology into their curricula. At a minimum, agricultural education provides hands-on, experiential, science and mathematics education that meet the demands for cross-curricular integration, and needs of students in the nontraditional settings. For example, SAEs and FFAs can incorporate current students and settings such as gardening projects in inner city summer programs or working for a greengrocer in the inner city neighborhoods.

In summary, agricultural education in the secondary and post-secondary schools serves the needs of the industry as well as the science, math and technology development needs of US students. Agricultural education is an experiential learning experience that provides a conduit for motivating students to learn science and mathematics, and provides hands-on practical experiences to complement theory.

Introduction

On September 17-19, 1999, a group of educators and others met in Ithaca, NY, to discuss not only workforce needs of the agriculture industry of the future, but also how to investigate and identify better ways of preparing that workforce. A central theme that evolved from discussions was that agricultural education could provide the context for preparing young people for adult roles, not just the workforce, which is only one aspect of adult life. This includes the notion that agriculture is an ideal context from which to teach science and mathematics.

This paper is prefaced by a section on agriculture as a context for teaching and learning. The balance of the paper is presented in the following sections: 1) summaries of the meeting and small group discussions, 2) recommended lines of inquiry for investigation of agricultural education as a vehicle to prepare children for adulthood, 3) an outline of the interdisciplinary nature of the recommended lines of inquiry, 4) policy issues identified through the meeting discussions, and 5) a summary of the literature on contextual teaching and learning.

A Summary of the Meeting

The group of participants met for Conference Registration and a reception on Friday, September 17, 1999. This provided the opportunity for the various individuals from across the country to meet one another and to begin discussions related to the conference. The major work activities were conducted on Saturday, September 18, and Sunday, September 19 and are briefly summarized below.

Saturday, September 18, 1999

The first major activity was a sharing of research interests and ideas among the participants. Dr. Donald Johnson, University of Arkansas, coordinated this activity. The interests of the group ranged from teacher development to study of levels of cognition in the college classroom to processes of integration. This activity was followed by one in which the participants were divided into four groups and provided with questions to focus their discussions. Eight major questions were addressed from the proposal:

- What unique learning demands--cognitive and psychomotor--are imposed in an environment that addresses technical skill development for application of scientific concepts and principles as opposed to an environment focused on pure vocational or academic content?

- How is information processed in a situation of technical skill development for application of scientific concepts and principles?

- How does transferability of knowledge and skills occur—across tasks—and as part of the decision-making process when solving a problem or approaching a task?
- What kinds of teaching and learning strategies are most appropriate to maximize transferability?

- Are working memory and long-term memory development and utilization different in an applied science or technical work environment as opposed to an environment focused on pure content (knowledge) acquisition? On abstract or creative thought?

- How does the notion of distributing cognition across individuals, tasks, and physical environments relate to meeting future workforce preparation needs?

- How does this concept of distributed cognition relate to a new kind of competence for thoughtful teaching—the ability to draw upon the knowledge and expertise of others and to contribute one's own knowledge in productive ways to the group?

- What new types of assessment may be necessary to accurately measure and evaluate learning in situations of transferability across tasks, distributed cognition, and other areas of performance which are emerging as part of the workplace?

Each group was provided with a question sheet that focused on two of the major questions from the proposal as outlined above, with a set of "guiding questions" to help them develop their responses (See Appendix).

Dr. Lowell Catlett, an agricultural economist from New Mexico State University, provided the keynote address at lunch. His talk focused on the changing workforce in agriculture and the need for educational institutions to be cognizant of those changes and the need for response to them. Following lunch, participants rotated among groups to engage in further discussion around the focus questions. A dinner cruise on Lake Cayuga provided additional opportunities for participants to engage in conversations related to the meeting.

Sunday, September 19, 1999

The initial activity on Sunday was to recap information from the previous day's discussions. Following that, participants divided into small groups for the purpose of addressing the type of information that should be conveyed to NSF as a result of the meeting. That information has been summarized and is presented in the recommendations section of this paper.

Small Group Discussions

Thorough records were kept of the small group discussions. The major foci of these discussions evolved around several key areas:

1. What is the real purpose of school, to prepare children for work or to prepare them for adulthood?

2. What information and skills transfer, how does the transfer occur, and what can we do to maximize the transfer?

3. Given the economic importance of the agriculture industry, how can we improve the image of agriculture and agricultural education to attract more students, particularly those bound for postsecondary education?

4. Given the experiential and leadership components of agricultural education programs, how can we promote its use as a vehicle for preparing all young people for the workforce and for their future roles as adults?

Recommendations for Research

We recommend an initial research phase with three lines of complementary scholarly inquiry that would culminate in the development of an experimental program that could be rigorously tested in the field (Figure 2):

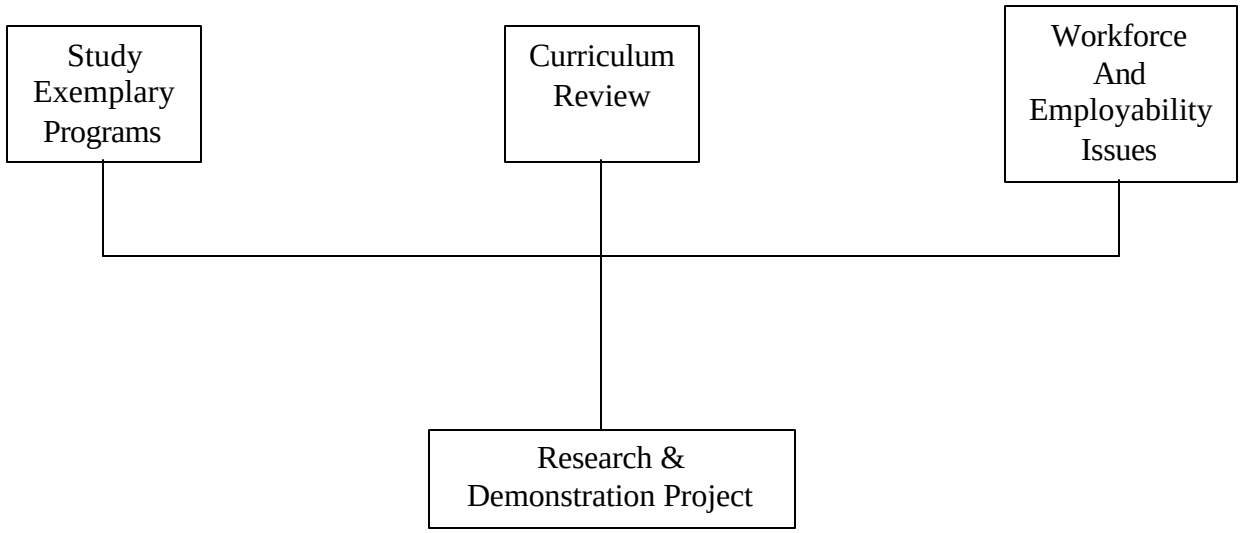

Figure 2. Agriculture as a Rich Context for Teaching and Learning, and for Learning Mathematics and Science to Prepare for the Workforce of the 21st Century

Study Exemplary Programs

Educational researchers have proposed that school is a place, that there should be cycles of learning that coincide with the natural world and school should be a place to interact with the natural world. Agriculture is an applied science that provides opportunities for this interaction with real-world, community-based situations.

Several fundamental assumptions undergird the rationale and identification of procedures for examining agricultural education programs that may be characterized as exemplary or effective. First, we should assume that programs that involve students in authentic activities should produce more desired changes, or the kinds of learning necessary for success in adult roles. Second, if we want to investigate these programs we would need to do case studies—ethnographic studies—that are more expensive and time consuming, but would producer richer evidence of what teachers and students are doing. These studies would involve the identification of exemplary programs and observation of what teachers and students do as well as how students change as a result of being in the program.

How do we identify an exemplary program?

Initial Criteria:

- Emphasize the learning of academic content as a significant focus of their instruction (not learning plant tissue culture to get a job doing that, but to learn the associated math and science competencies).

Several areas of scholarly inquiry should be pursued in the investigation of exemplary programs:

Research Question #1:

What do existing exemplary agricultural education programs do?

1a. What types of assessment practices are in place? Is standardized testing required?
1b. What do students value? Why do they choose particular teachers and courses?
1c. How does competition for grades among students impact on motivation and sense of self-efficacy?
1d. What are parents' understandings of the program, their perceptions, and levels of acceptance?
1e. How do institutional structures impact the program?
1f. Do teachers "buy into" integration and to what extent do they integrate?

Research Question #2:

Is there any evidence of differential impact on different kinds of students?

2a. Do programs that provide contextual teaching and learning promote *affective* change in academically talented students?

2b. What kinds of positive impacts on "at risk" youth can be attributed to the program?
2c. What kinds of student characteristics, i.e. family size, may impact on students' ability to work on a team?
2d. Are there unique and possibly undiscovered instructional strategies that are appropriate to teaching in an authentic context for the purpose of improving transfer, especially for the middle 50% of students?
2e. How are different "entry points" into mathematics and science identified and actualized for different types of students?

Research Question #3:

Does learning in context improve transferability of mathematics and science learning? Of life skills?

3a. Is there a difference in retention of learning in a vocational vs. an academic classroom?
3b. Assuming that transfer requires risk-taking, self-efficacy, and confidence, does learning in context improve these processes and lead to enhanced transfer?
3c. What is the relationship between learning in context, retention, and recall? Does it work the same for mastery of a complex process?
3d. What is the role of reflection to stimulate transfer? Transfer may relate to students' reasoning and analytical abilities. Can you teach these things?
3e. What is the appropriate balance of skills training vs. instruction in concepts?
3f. At what age level should skills training, as a vehicle to learn academic skills, be introduced?
3g. Attributes needed for transfer include skills such as time-management or organizing the task structure. Transfer also requires the use of cognitive strategies such as evaluating your present knowledge and needed knowledge and monitoring your progress. Success in a job requires not only being able to transfer knowledge, but also development of the "soft skills." Does learning in context develop some of the requirements for successful transfer of all of these aspects—cognitive strategies, knowledge, and soft skills?
3h. Does contextual teaching and learning provide for sustained exposure and reinforcement of key concepts, thereby increasing the possibility for transferability?

Research Question #4:

What should we be teaching?

4a. Does a thematic approach/contextual teaching and learning lead to less breadth of content, but more depth of content acquisition as well as the skills?
4b. What is the extent and nature of integration and the relationship to transfer?

Research Question #5:

How can agriscience/agricultural education make the greatest contribution to the mission of the school, whatever that is?

5a. What role can the agricultural education program play in the introduction of issues and ethics into the school curriculum?
5b. What are the relationships between this (issues and ethics) and transition from childhood to the workforce?
5c. What is the interface between science education and agricultural education in terms of pedagogy—teaching methods and content; What are the defining areas of science within the applied areas of agriculture?
5d. How does contextualized learning increase motivation for lifelong learning?

Research Question #6:

What role does assessment play in the transition from childhood to the workforce?

6a. How do you assess experiential learning, internships, service learning, all integral components of a contextualized learning environment?
6b. What role does student self-assessment and peer evaluation play, within the context of agriscience, for preparation for adult roles?
6c. What is the relationship between participation in an authentic learning experience and the development of an intrinsic motivation to learn?

A Thorough Curriculum Analysis

It is important to examine the official curriculum in agriculture education that exists both in the exemplary programs that are investigated as well as those states that mandate a curriculum. This would serve the purpose of documenting what exists at this time as well as permitting a projection to the future and what may need to be changed in order to match existing science and mathematics standards.

Several areas of inquiry have been identified as part of the curriculum analysis phase of the recommended research agenda; several of these areas overlap with and would occur simultaneously and as part of the examination of exemplary programs:

Research Question #7:

What is the relationship between the school curriculum and adult life roles?

7a. What should be changed in order for the curriculum to better match mathematics and science standards?
7b. What is the depth of science instruction within the curriculum?
7c. What is the relationship between the existing curriculum and adult life roles?
7d. Does a thematic approach/contextual teaching and learning lead to less breadth of content, but more depth of content acquisition as well as the skills?
7e. What is the extent and nature of integration and the relationship to transfer?

Research Question #5:

How can agriscience/agricultural education make the greatest contribution to the mission of the school, whatever that is?

5e. To what extent are issues and ethics introduced into the curriculum? To what extent are these areas identified by students, a part of the community, and/or tied to more global ethnical issues?
5f. What is the interface between science education and agricultural education as outlined in the curriculum?
5g. What assessment strategies are outlined within the curriculum, particularly for experiential activities such as internships, SAEs, service learning activities, etc.?
5h. To what extent does the curriculum allow for student self-assessment and peer evaluation?
5i. To what extent does the curriculum indicate an understanding of the importance of the factors related to transferability such as in-depth learning of initial concepts, recognition of similarities in situations, and seeking out domain-specific knowledge?

An Analysis of Workforce and Employability Issues

Previous research on the workforce and employability has tended to focus on who gets what types of jobs, what (behaviorally determined) tasks they perform on the job, and what social, human, and process skills employers have identified as necessary for success on the job. We recommend a mixed methods approach to examine some of the more abstract areas of workforce and employability as well as the relevance of work to the school curriculum. Several of these areas overlap with and would occur simultaneously and as part of the examination of exemplary programs and the curriculum analysis:

Research Question #8:

What is the meaning that workers give to their work?

8a. What sense do workers make of the skills they perform? Do they view tasks they perform as routinized skills vs. seeing their job skills as part of a larger process?
8b. Ethnographic research is needed to determine what competencies are truly important to success in the workplace. What is the rhetoric vs. the reality of what workers need to know and be able to do?
8c. What relevance is there for current academic and other content that is presented in the public schools?

Research and Demonstration Program

The thorough examination of exemplary programs, curriculum, and workforce and employability issues as outlined above should be followed by a research and demonstration program that would build on the results. We propose the development of a complete curriculum

in aquaponics as the specific context for teaching and learning. A limited number of pilot sites would implement the aquaponics curriculum at various levels and provide for case study research to examine the effects of its implementation, specifically the cognitive and affective outcomes as well as transferability. Lines of inquiry to follow in this phase are

Research Question #2:

Is there any evidence of differential impact on different kinds of students?

2a. Do programs that provide contextual teaching and learning promote *affective* change in academically talented students?
2b. What kinds of positive impacts on "at risk" youth can be attributed to the program?
2c. What kinds of student characteristics, i.e. family size, may impact on students' ability to work on a team?
2d. Are there unique and possibly undiscovered instructional strategies that are appropriate to teaching in an authentic context for the purpose of improving transfer, especially for the middle 50% of students?
2e. How are different "entry points" into mathematics and science identified and actualized for different types of students?

Research Question #3:

Does learning in context improve transferability of mathematics and science learning? Of life skills?

3i. Is there a difference in retention of learning in a vocational vs. an academic classroom?
3b. Assuming that transfer requires risk-taking, self-efficacy, and confidence, does learning in context improve these processes and lead to enhanced transfer?
3c. What is the relationship between learning in context, retention, and recall? Does it work the same for mastery of a complex process?
3d. What is the role of reflection to stimulate transfer? Transfer may relate to students' reasoning and analytical abilities. Can you teach these things?
3e. What is the appropriate balance of skills training vs. instruction in concepts?
3f. At what age level should skills training, as a vehicle to learn academic skills, be introduced?
3g. Attributes needed for transfer include skills such as time-management or organizing the task structure. Transfer also requires the use of cognitive strategies such as evaluating your present knowledge and needed knowledge and monitoring your progress. Success in a job requires not only being able to transfer knowledge, but also development of the "soft skills." Does learning in context develop some of the requirements for successful transfer of all of these aspects—cognitive strategies, knowledge, and soft skills?
3h. Does contextual teaching and learning provide for sustained exposure and reinforcement of key concepts, thereby increasing the possibility for transferability?

Research Question #6:

What role does assessment play in the transition from childhood to the workforce?

6a. How do you assess experiential learning, internships, service learning, all integral components of a contextualized learning environment?
6b. What role does student self-assessment and peer evaluation play, within the context of agriscience, for preparation for adult roles?
6c. What is the relationship between participation in an authentic learning experience and the development of an intrinsic motivation to learn?

Research Question #9:

What do parents and others in the community think of an applied curriculum? The focus on contextual teaching and learning?

9a. What are parents' perceptions of a thematic curriculum? How do they perceive an applied curriculum?
9b. What do various community members and stakeholders think of the thematic curriculum? How do they perceive an applied curriculum?
9c. What perceptions to parents and others in the community hold about the relationship of the school curriculum to the workforce and employability?

Research Question #10:

What changes are needed in teacher education to accommodate the new curriculum and the contextualized teaching and learning environment?

10a. What characteristics denote a quality teacher education program that promotes contextualized teaching and learning?
10b. What kinds of knowledge, experiences, and values should teachers possess?
10c. Do you have to educate teachers differently to work within an integrated curriculum? In a contextualized teaching and learning situation?

Identification of Areas of Interface and Intersection for Interdisciplinary Research

The following table identifies areas of potential areas of interface and intersection for interdisciplinary research that would be possible in carrying out the recommended research agenda outlined in this paper:

Table 1.

Identified Areas of Interface and Intersection for Interdisciplinary Research

Research Question	Areas of Inquiry	Potential for Interdisciplinary Research
Research Question #1:	Assessment practices.	Agricultural education
	Student values	Educational psychology
What do existing exemplary	Competition & self-efficacy	Behavioral psychology
agricultural education	Parent perceptions	Family studies
programs do?	Institutional structures?	Educational administration
	Integration	Curriculum specialists
Research Question #2:	Affective change	Agricultural education
	Impact on at-risk youth	Educational psychology
Is there evidence of	Impact of family	Special education
differential impact on different	characteristics	Family studies
kinds of students?	Instructional strategies	Teacher education
	Entry points for math/science	Math/science education
Research Question #3:	Vocational vs. academic	Agricultural education
	Self-actualization, soft skills	Vocational education
Does learning in context	Retention & recall	Cognitive psychology
improve transferability of	Reflection	Educational psychology
math & science? Of skills?	Skills vs. concepts	Developmental psychology
	Age to introduce skills	Math/science education
	Transfer	
Research Question #4:	Breadth vs. depth	Agricultural education
	Integration	Math/science education
What should we be teaching?		Curriculum specialists
Research Question #5:	Issues/ethics education	Agricultural education
	Transition to adulthood	Vocational education
How can agricultural	Science education	Educational psychology
education make the greatest	Lifelong learning	Developmental psychology
contribution to the mission of		Math/science education
the school, whatever that is?		Adult education
Research Question #6:	Non-academic assessments	Agricultural education
	Self-assessment	Educational psychology
What role does assessment	Intrinsic motivation to learn	Teacher education
play in the transition from		Cognitive psychology
childhood to the workforce?		Developmental psychology
Research Question #7:	Needed changes	Agricultural education
	Depth of math/science	Curriculum specialists
What is the relationship	Relationship to adult roles	Developmental psychology
between the school curriculum	Breadth vs. depth	Teacher education
and adult life roles?	Integration	Math/science education

Table 1, Continued

Research Question	Areas of Inquiry	Potential for Interdisciplinary Research
Research Question #8: *What is the meaning that workers give to their work?*	Worker perceptions of work Necessary competencies Relevance of school to work	Agricultural education Vocational education Adult education Human resources
Research Question #9: *What do parents and others think of an applied curriculum?*	Perceptions of parents Perceptions of community members Relevance of curriculum	Agricultural education Curriculum specialists Educational psychology
Research Question #10: *What changes are needed in teacher education?*	Quality program focused on contextualized learning Knowledge, skills, and values needed Changes needed	Agricultural education Teacher education

Policy Implications

It is not possible to complete this paper without an attempt to identify areas of concern as expressed by participants, particularly regarding educational policy. Participants were not, in general, convinced that much change in public school education would be possible without sweeping changes in current policy structures. The following represents a summary of the policy items identified and discussed during the meeting:

- Standardized testing and other forms of assessment. How does standardized testing influence the adoption of classroom innovation (or lack of adoption)? How does it influence effective teaching? What does standardized testing do to teacher practice, over time?

- Is it possible to measure experiential learning in such a way as to incorporate assessment of standards? What about standardized testing? Agricultural education uses experiential education. What are the appropriate assessment techniques for internship, service learning, and other types of experiential learning?

- How can we convince policy makers to make decisions based on educational sense and not economic sense?

- How do institutional structures such as block scheduling impact the ability to teach processes such as problem solving? How do year-round schedules impact agricultural education and other programs?

- How are teachers, superintendents, others evaluated? What is the University reward system? How does this filter down into the classroom and teacher behaviors? Do these reward systems impact transition to adulthood for children and their subsequent success in the workforce?

- What is the role of the teacher in the modern school? What is the teacher educator's role in preparation of the modern teacher?

- Who is responsible for on-the-job training?

A Summary of the Literature on Contextual Teaching and Learning

In order to provide a clarification of the notions and concepts expressed in this paper the following represents a summary of the literature on contextual teaching and learning. Our discussion of contextual teaching and learning evolves from the following initial hypothesis:

> High school programs that involve students in authentic activities will produce the kinds of changes necessary to prepare children for adulthood.

The Colleges of Education at The Ohio State University and Bowling Green State University received funding in 1998 from the U.S. Department of Education to conduct a national design conference for the purpose of developing a framework to advance the preparation of teachers to use contextual teaching and learning strategies. Organizers of the conference defined contextual teaching and learning as

> … teaching that enables learning where pupils employ their academic understandings and abilities in a variety of out-of-school contexts to solve complex, real world problems, both alone and in various dyad and group structures. These activities make connections with their roles and responsibilities as family members, citizens, students and workers. Learning in these activities is commonly characterized as active, self-regulated, problem-oriented and responsive to a host of diverse learner needs and interests. Assessment is on going and blended with this teaching and learning; it is reciprocal in nature with evaluation of both activities. Contextual teaching and learning emphasizes higher-level thinking, knowledge transfer, collecting, analyzing and synthesizing information and data from multiple sources and viewpoints. [Ohio State University, 1998)

Because it is a new phrase in the lexicon of educational terminology, the actual concept of contextual teaching and learning is not addressed to any great extent in the literature; however, there is a relevant research base in areas identified in the above definition. These areas include problem-based learning, self-regulated learning, service learning, work-based learning, and authentic assessment. Contextual teaching and learning may be viewed as a holistic approach to instruction utilizing all of the necessary strategies to connect students to their world outside of the classroom.

Teaching methods can be arranged on a continuum with "Lectures" at one end as the most structured to "Authentic Situations" at the other end as the least structured (Figure 3).

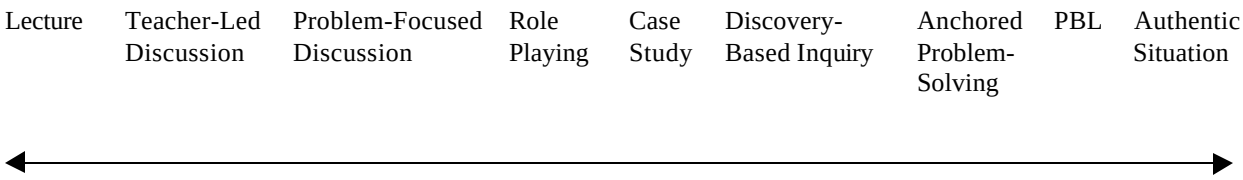

Figure3. Taxonomy of Approaches to Learning

Source: Finkle, S., 1995, as cited in Pierce, 1998.

In using the case study approach, the instructor provides a well-structured example of a situation either before or after the content that applies to the case. Discovery-based inquiry is another example of a well-structured approach in which most of the information is presented by the teacher. In this approach, the instructor guides students' efforts with strategically placed clues and suggestions. Anchored-problem solving is learning that is situated in an elaborate case with information presented "incidentally." Students are challenged to seek out the information and clues necessary to identify and solve the problem. The difference between anchored-problem solving and PBL is that in PBL students must define and investigate the problems themselves. Situations may be unstructured or "messy" and students become involved in the problem, assuming the role of a stakeholder (Pierce, 1998).

Problem-Based Learning

Problem-based learning (PBL) has been around for about 30 years. As a methodology, it involves introducing students to a simulated or real problem for which they are expected to integrate information from various disciplines to find the solution. While the teacher will provide some information to students, they must seek additional information in order to further define the issues and determine all available solutions. The problem may, in fact, be redefined as students continue their investigation. According to Finkel (1998 as cited in Pierce, 1998) the instructional sequences that must be present for an approach to qualify as PBL are

- Engagement. This includes 1) preparing for the role of being a self-directed problem solver who will collaborate with others, 2) encountering a situation that invites students to find problems, and 3) searching for the nature of the problem while proposing ideas, hunches, possible solutions, plans to solve, etc.

- Inquiry and investigation. This involves 1) exploring identified ways to explain events and the implications of each and 2) gathering and sharing information.

- Performance. This step involves the presentation of the results of the investigation.

- Debriefing. Students engage in 1) examining the costs and benefits of each solution generated and 2) reflection on the approaches they have used to solve the problem.

It should be noted that there is no implied or required sequence to the teaching-learning events. Some of the PBL efforts currently identified in the literature are service learning, action research, and computer supported intentional learning environments.

Research on the effects of PBL on achievement of medical school students revealed that students engaged in PBL programs tended to score lower on standardized tests of basic science, but had superior long term recall for the information that was covered. There was also a trend for these students to rate higher on their clinical skills vs. students prepared in a traditional program (Albanese & Mitchell, 1993; Coulson, 1983; Vernon & Blake, 1993; as cited in Pierce, 1998).

In summary, problem-based learning is an appropriate strategy for use in programs designed to prepare students for careers that involve ill-structured problem solving. According to Pierce (1998) they "become apprentices who experience the difficulties and processes inherent in constructivism. Messy problems require cognitive and metacognitive strategies that facilitate their work" (p. 21). Students wrestle with authentic problems, learning information and problem solving processes that they will need in their adult roles.

Self-Regulated Learning

According to Paris and Winograd (1998) self-regulated thinking and learning (SRL) has three major characteristics: awareness of thinking, use of strategies, and sustained motivation. Research has shown that children between the ages of 5 and 16 evolve into an increasing awareness of their own knowledge states, characteristics of tasks that influence learning for them individually, and their own strategies for monitoring learning (Brown, Bransford, Ferrara, & Campione, 1983; Flavell, 1978; as cited in Paris and Winograd, 1998). Self-regulated learning involves not simply thinking about thinking for children, but assisting them in using this thinking to guide their plans, select strategies for learning, and interpret their own performance so that they can effectively solve problems presented to them.

Strategic thinkers understand how to discriminate between productive and unproductive problem-solving strategies as opposed to just knowing about a strategy and its use. They understand how to consider options before choosing a solution or strategy. According to Paris and Winograd (1998) these choices embody SRL because they result from cognitive analyses of alternative routes to problem solving. Paris and Winograd (1998) also identified sustained motivation as an aspect of SRL. They stated that self-directed actions involve motivation decisions about the desired outcomes for the activity as well as its perceived difficulty and the learner's perceptions as to whether he/she can effectively accomplish the task. Paris and Winograd (1998) developed five principles for the enhancement of self-regulation among both teachers and students:

1. *Self-appraisal leads to a deeper understanding of learning*. This includes a) analyzing personal styles and strategies for learning and comparing them to others, b) evaluating what you know and what you do not know as well as discerning the personal depth of understanding to promote efficient effort allocation, and 3) periodic self-assessment of learning processes and outcomes to promote monitoring of progress, stimulate repair strategies, and promote feelings of self-efficacy.

2. *Self-management of thinking, effort, and affect promotes flexible approaches to problem solving that are adaptive, persistent, self-controlled, strategic, and goal-oriented.* Self-regulated learning is not a list of steps to follow or a menu of options. Rather, it is a set of dynamic actions of learners as they engage in problem-solving exercises. The learners adapt to changing circumstances and know how to respond to challenges. If goals are set by others, behavior is "obedient" or "compliant" instead of self-directed. Goal setting involves the following guidelines: a) Setting appropriate goals that are attainable yet challenging is most effective when goals are chosen by the individual and when they embody a mastery orientation rather than a performance goal, b) Managing time and resources through effective planning and monitoring is essential to setting priorities, overcoming frustration, and persisting to task completion, and c) Reviewing one's own learning, revising the approach, or even starting anew, may indicate self-monitoring and a personal commitment to high standards of performance.

3. *Self-regulation of learning and thinking develop over time, change with experience, and are never static or complete.* Self-regulation can be enhanced through reflection and discussion. Children also demonstrate an increasing awareness of their own mental and motivational processes as the age, partly due to developmental growth and partly due to school experiences. Self-regulation may be automatic or deliberate at different times.

4. *Self-regulation can be taught in diverse ways.* Self-regulated learning begins with the learner and not a list of tactics. Components of SRL should be included in what is taught and what is expected of students: a) Self-regulation can be taught with explicit instruction, directed reflection, and metacognitive discussions, b) Self-regulation can be promoted indirectly by modeling and by activities that entail reflective analysis of learning, and c) Self-regulation can be promoted by assessing, charting, and discussing evidence of personal growth.

5. *Self-regulation is woven into the narrative experiences and the identity of each* person's identify (Lave & Wegener, 1994, as cited in Paris & Winograd, 1998). How individuals choose to appraise and monitor their own behavior is usually consistent with their preferred or desired identity. In addition, gaining an autobiographical perspective on education and learning provides a narrative framework that deepens personal awareness of self-regulation. Finally, participation in a reflective community enhances the frequency and depth of examination of one's self-regulation habits. (Paris & Winograd, 1998, p. 3-9)

Service Learning

Service learning is a pedagogical method in which performance of service activities form the basis and context for the learning experiences. It differs from community service activities that are usually conducted as extracurricular volunteer activities (Wade, 1998). Examples cited

by Wade include building park benches or playground equipment, writing to servicemen or senior citizens, and developing a nature trail. Service learning experiences also focus on needs or problems within the community in which the school is located such as tutoring projects, advocacy activities, and public education. Advocates of service learning believe that it positively influences youth development in many ways:

- Academic skills. There is little research on academic achievement for students participating in experiential programs. Studies focused on use of service learning for students with low academic achievement found that they were likely to experience gains in achievement if the assessments closely matched their service experience (Conrad, 1991; Williams, 1991, as cited in Wade, 1998).

- Social and Personal Development. Self-esteem, personal responsibility, and social responsibility are the most frequently assessed aspects of student development through service learning programs. The most consistent findings are that participatory programs do enhance self-esteem and promote personal development; data from empirical studies support the consensus of opinion expressed by students and teachers about positive gains in this area (Alt & Medrich, 1994, p. 9, as cited in Wade, 1998). A number of studies also report gains in social and personal responsibility (Conrad & Hedlin, 1991).

- Political Efficacy. Wade (1998) reported that the findings on whether or not service learning enhances political efficacy are mixed. In general, participants in programs that did not tie their activities to political issues or organizations were not likely to increase political efficacy.

- Future Civic Participation. Evidence from studies on future civic participation of service learning participants suggests that service-learning experience in one's youth has a positive impact. Wade (1998) cited two major studies that revealed that early service experience is a strong predictor of volunteering for both teens and adults. The role of schools was also found to be significant—students who were asked to serve their communities through school activities were more than three times as likely to become involved in future civic activities.

In summary, while the research revealed inconsistencies in each of the areas identified above, consistent and strong positive findings exist in the areas of personal and social development and future civic participation. Inconsistencies in the findings on student outcomes can be partly attributed to individual program characteristics. For example, educators have noted the importance of time spent on reflection, duration and intensity of the service learning experience, and a clear match between the service experience and overall program goals (Wade, 1998). In addition to the positive outcomes in the areas of personal and social development and future civic engagement, every study on service learning reveals that participants, teachers, parents, and community members agree, overwhelmingly, that the programs are "worthwhile, useful, enjoyable and powerful learning experiences" (Conrad, 1991, cited in Wade, 1998).

Work-Based Learning

Work-based learning (WBL) provides students with an opportunity to learn in environments outside the school setting in order to help them make connections with what they

are learning in school and what occurs in work activities. Work-based learning has its roots in the apprenticeship movement, which developed early in U.S. history and found its way into cooperative education programs in public high schools in the late 1800s. It (WBL) includes a combination of school-based instruction, actual work activities, and on-the-job training (Lynch & Harnish, 1998).

Current practice in WBL is grounded in the cognitive science research on teaching and learning, and focuses on an integrated curriculum. According to Lynch & Harnish (1998), the ideal integrated curriculum

> should involve both mind and matter, theoretical and applied, and vocational and academic, all of which seem to result in increased retention of knowledge, deeper understanding of subject matter, and application of knowledge and skills in ill-structured environments (i.e., transfer) for most students most of the time. Classroom and work-based activities draw also on psychology and pedagogy that speak to constructivism, contextual learning, teaching concepts and subjects through a variety of methods based on students' preferred learning styles, and authentic assessment. It parallels much of which has been learned through research on learning and training in workplaces. (p. 2)

Lynch and Harnish (1998) further explained WBL by operationally defining it as

> an educational approach that uses work places to structure learning experiences that contribute tot he intellectual, social, academic, and career development of students and supplements these with school activities that apply, reinforce, refine or extend the learning that occurs at a work site. By so doing, students develop attitudes, knowledge, skills, insights, habits, and associations from both work and school experiences and are able to connect learning with real life work activities. (p. 2-3).

Work-based learning programs can contain a continuum of experiences based on the purposes and resources of the program. Experiences at the early stages of the continuum usually involve activities geared toward career awareness; some schools begin these activities in elementary education. The National 4-H youth organization also begins career awareness activities in the elementary grades. Later experiences should build on these activities by providing students with opportunities to learn more about the culture and expectations of the workplace. At the end of the continuum are activities designed to assist students to learn actual knowledge, skills and attitudes associated with particular careers (Lynch & Harnish, 1998).

Lynch and Harnish (1998) cited three major arguments for use of work-based learning strategies in education:

1. Economic arguments. Employers are concerned that high school graduates are not being prepared with the knowledge, skills and attitudes needed in today's economy and information-age jobs, for entry level as well as more advanced professional and technical work. They recognize education's contribution to economic growth and its effect on business and

industry's ability to compete in a global marketplace. Competitive economic advantage is linked to the skills of the workforce, which makes education and training a high stakes issue for many communities.

2. Philosophical arguments. The purpose of education has been part of the recent discussions regarding educational reform. Carnevale (1994, as cited in Lynch & Harnish) referred to a three-part mission of education of teaching students to be a) good neighbors (community role), b) informed and involved citizens (political role), and c) qualified workers (employment role). The latter role is seen as the key to meeting the others since society and individuals, themselves, base identity on careers, work skills, and the ability to be self-supporting. School should prepare students for economic participation, job training, skills for continued learning outside of school, and civic and cultural contributions. This can be accomplished by teaching higher order cognitive abilities, reflection, and reasoning through an education grounded in real-life experiences and applications as a broader preparation for life, which includes work.

3. Learning arguments. Research suggests that students learn more and retain it longer when they are required to deal with real world problems and learn knowledge in the context in which it is actually used. School has not been found to adequately address the social means by which work tasks are established, or to provide the best environment to teach the knowledge and skills required for any particular occupation. It must be noted that WBL approaches do not just work for some students (vocational) and that learning can be improved for college preparatory students, as well. (p. 6-9)

Early studies examining use of WBL approaches provide positive indication of its impact on student achievement, motivation, and likelihood of entering postsecondary education. In these studies, WBL benefited all students, including the college bound. Participants had higher grades and class rank and significantly reduced absences when compared to non-participants (Hollenbeck, 1996; Stern, Raby & Dayton, 1992, as cited in Lynch and Harnish, 1998). Others (Bailey & Merrit, 1997) found that WBL experiences strengthened and increased the amount of basic knowledge that was learned, understand, and retained, as well as increasing the motivation for continued academic studies.

Authentic Assessment

Darling-Hammond and Snyder (1998) have defined authentic contextualized assessment as assessment that meets five conditions:

1. Assessments sample the actual knowledge, skills, and dispositions desired of students, requiring the integration and use of knowledge and skills, and including actual examples of work.

2. Assessment is tightly interwoven with learning opportunities and aligned with the program's content, desired outcomes, and instructional practices.

3. There are multiple opportunities for learning, practicing, and assessing the desired outcomes so that assessment helps develop competence, not just measure it. In addition, good support and evaluation requires multiple sources of evidence that are collected over time. The program should provide structures and processes aligned with desired outcomes (i.e., standards). An isolated assessment is insufficient to inform learning, teaching, program development, or judgments about students' competence.

4. Assessment includes feedback and reflection loops.

5. Assessments allow students to exhibit the desired knowledge, skills, and dispositions in contexts of different kinds.

The use of authentic assessment practices has been found to influence the learning of students, the learning of teachers, and program improvement. At issue, however, are costs, feasibility, and how and if these practices can be used in high stakes decisions such as graduation and professional licensing.

Contextual Teaching and Learning and Transferability

Lee (1999) defined transfer as the "ability to think and reason about new situations through using previous knowledge" (p. 1). Transfer can be either positive, where learning or problem solving is enhanced through the use of previous knowledge, or it can be negative, where previous knowledge actually hinders the learning process. Research on the transfer of general skills seems to be inconclusive, but it is evident that students have difficulty transferring a solution from one problem to another problem when the situations appear different to them (Lee, 1999). Transfer also is said to occur *within domains*, or performing similar task in the same domain or closely related subject area, or *across domains*, or where knowledge is acquired in one situation or subject area and then used in a second domain.

The most recent theories of transfer are those espoused by Singley and Anderson (1989, as cited in Lee, 1999) and involve the use of production rules, or a series of If-Then statements. Transfer should occur where production rules are similar between tasks, or where similarity is defined by the numbers of shared production rules between tasks. Stating this in a more concrete way, common elements transfer. One example would be that the same rules that apply to driving a car should apply to driving a truck (Lee, 1999).

Production rules are specific for any task that is learned, but environmental cues that are present when the recall is expected can result in faster recall. In addition, research has shown that knowledge or tasks in the first domain must be learned to a high level in order to transfer. Transfer is believed to occur along a continuum from "near transfer" that occurs within the same domains to "far transfer" that occurs across domains. To build on this, Lee (1993, as cited in Lee, 1999) cites three keys to transfer:

1. Knowledge from the first domain (initial learning situation) is acquired prior to attempts to transfer that knowledge to another situation. In order for transfer to occur, the initial

learning must be strong. There is also between transfer and the depth of learning as well as the creativity of the learning in the application of previous knowledge to a new situation.

2. The knowledge utilized in two situations must have overlapping production rules, which enables the individual to notice the similarities between the initial situation and the subsequent situation. If the individual lacks domain-specific knowledge to solve a problem in the second situation, he/she needs to be capable of recognizing the need and seeking out this knowledge.

3. A person starts to apply previous knowledge to very new situations when he/she is highly skilled in the first domain. Questions remain as to how much training and experience are needed for this transfer to begin.

Ways to improve transfer should improve intellectual functioning (Lee, 1999). Lee (1999) also contended that people develop reasoning strategies with in one context, but can fail to access these strategies for reasoning in another domain. The research she cited seems to indicate that training in memory strategies, memory monitoring strategies, and reflection on the strategies may promote a "liberation of the strategy from the domain and its subsequent availability for use in another domain" (Lee, 1999), p. 19). Learning in context should assist students to learn, to depth, content in one or several related domains. It should also enable them to recognize not only similarities between new situations, to see the social context in which problems are addressed and solved, and to transfer this learning to slightly different situations and, therefore, help maximize transfer.

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